1. A star will spend most of its life
   A) as a protostar.
   B) in repeated swellings to the red giant.
   C) on the main sequence.
   D) inside its planetary nebula.
   E) in a sustained helium flash lasting billions of years.

2. When a star's inward gravity and outward pressure are balanced, the star is said to be
   A) in thermal expansion.
   B) in gravitational collapse.
   C) in hydrostatic equilibrium.
   D) a stage 2 protostar.
   E) in rotational equilibrium.

3. What temperature is needed to fuse helium into carbon?
   A) 100,000 K
   B) 15 million K
   C) 100 million K
   D) 400 million K
   E) 10 billion K

4. When a low mass star first runs short of hydrogen in its core, it becomes brighter because
   A) its outer, cooler layers are shed, and we see the brighter central core.
   B) helium fusion gives off more energy than does hydrogen.
   C) the core contracts, raising the temperature and hydrogen burning shell outward.
   D) it explodes as a nova.
   E) the helium flash increases the size of the star immensely.

5. A star is on the horizontal branch of the H-R diagram. Which statement is true?
   A) It is burning both hydrogen and helium.
   B) It is about to experience the helium flash.
   C) The star is contracting.
   D) The star is about to return to the main sequence.
   E) It is burning only helium.

6. The helium flash converts helium nuclei into
   A) beryllium.
   B) boron.
   C) oxygen.
   D) carbon.
   E) iron.

7. During the hydrogen shell burning phase
   A) hydrogen is burning in the central core.
   B) the star grows more luminous.
   C) helium is burning in the core.
   D) the star becomes less luminous.
   E) the core is expanding.

8. Can a star become a red giant more than once?
   A) yes, before and after the Type II supernova event
   B) no, the planetary nebula blows off all the outer shells completely
   C) no, it will lose so much mass as to cross the Chandrasekhar Limit
   D) no, or we would see them as the majority of naked-eye stars
   E) yes, before and after the helium flash

9. A solar mass star will evolve off the main sequence when
   A) it completely runs out of hydrogen.
   B) it loses all its neutrinos, so fusion must cease.
   C) it expels a planetary nebula to cool off and release radiation.
   D) it builds up a core of inert helium.
   E) it explodes as a violent nova.

10. A white dwarf has the mass of the Sun and the volume of
    A) Mars.
    B) the Moon.
    C) Eros.
    D) Earth.
    E) Jupiter.

11. The outward pressure in the core of a red giant balances the inward pull of gravity when
    A) the electrons and protons have combined to form neutrons.
    B) iron forms in the inner core.
    C) carbon fuses into heavier elements.
    D) the electrons are compressed so much they are all in contact.
    E) hydrogen begins fusing into helium.

12. Which of these is true of planetary nebulae?
    A) They are the envelopes that form when blue stragglers merge.
    B) They are ejected envelopes surrounding a highly evolved low mass star.
    C) They are rings of material around protostars that will accrete into planets in time.
    D) They are expelled by the most massive stars in their final stages before supernova.
    E) They are the material which causes the eclipses in eclipsing binary systems.

13. Compared to our Sun, a typical white dwarf has
    A) a smaller mass and and half the density.
    B) about the same mass and density.
    C) about the same mass and a million times higher density.
    D) a larger mass and a 100 times lower density.
    E) a smaller mass and twice the density.

14. A ________ represents a relatively peaceful mass loss as a giant core becomes a white dwarf.
   A) supernova remnant.
   B) nova.
   C) emission nebula.
   D) supernova.
   E) planetary nebula.

15. A surface explosion when a companion spills hydrogen onto its close white dwarf companion creates a
   A) Type I supernova.
   B) Type II supernova.
   C) planetary nebula.
   D) emission nebula.
   E) nova.

16. Which of these evolutionary paths is the fate of our Sun?
   A) supernova of type II
   B) planetary nebula
   C) brown dwarf
   D) nova
   E) pulsar

17. When the outer envelope of a red giant recedes, the remaining carbon core is called a
   A) planetary nebula.
   B) black hole.
   C) white dwarf.
   D) black dwarf.
   E) brown dwarf.

18. The initial mass of a protostar generally determines the star's future evolution. But in many cases, what can alter this process?
   A) The star may collide with another, unrelated star.
   B) The star may be isolated in space, far from other influences.
   C) The star may drift away from the other stars in its formation cluster.
   D) The star may be in a spectroscopic binary system.
   E) The star may gain mass by passing through a dark cloud.

19. Black dwarfs are
   A) often made from very low mass protostars that never fuse hydrogen
   B) not found yet; the oldest, coldest white dwarf in the Galaxy has not cooled enough yet
   C) rare, for few binary systems are close enough for this merger to happen
   D) rare, for collapsing cores of over three solar masses are uncommon
   E) very common, making up the majority of the dark matter in the universe

20. Virtually all the carbon-rich dust in the plane of the galaxy originated in
   A) high-mass stars.
   B) Type II supernovae.
   C) low-mass stars.
   D) Type I supernovae.
   E) the carbon cores of Type O stars.

21. You observe a low-mass helium white dwarf. What can you conclude?
   A) Its core is mostly carbon.
   B) It is over 100 billion years old.
   C) It will soon be a Type II supernova.
   D) It is part of a binary star system.
   E) It was once a blue supergiant.

22. Of the elements in your body, the only one not formed in stars is
   A) aluminum.
   B) carbon.
   C) calcium.
   D) iron.
   E) hydrogen.

23. An iron core cannot support a giant star because
   A) iron is too dense, and produces too much gravity.
   B) iron cannot fuse with other elements and produce additional energy in fusion.
   C) iron cannot fuse with any other elements at all.
   D) iron has a poor binding energy, and decays rapidly into lead.
   E) iron is heavy, and settles to the earth's core.

24. A 20 solar mass star will stay on the main sequence for 10 million years, yet its iron core can exist for only a
   A) month.
   B) century.
   C) week.
   D) day.
   E) year.

25. As a star's evolution approaches the Type II supernova, we find
   A) photodisintegration of iron nuclei begins at 10 billion K to ignite the supernova.
   B) the heavier the element, the less time it takes to make it.
   C) the heavier the element, the higher the temperature to fuse it.
   D) helium to carbon fusion takes at least 100 million K to start.
   E) All of the above are correct.

26. As a 4-10 solar mass star leaves the main sequence on its way to becoming a red supergiant, its luminosity
   A) decreases.
   B) remains roughly constant.
   C) increases.
   D) first increases, then decreases.
   E) first decreases, then increases.

27. Which of the following best describes the evolutionary track of the most massive stars?
    A) horizontally right, diagonal to lower left, then horizontal right
    B) horizontal right, then a clockwise loop
    C) vertically left, then straight down
    D) horizontal right
    E) diagonally to lower right, then vertical, then horizontal left

28. Type II supernovae occur when their cores start making
    A) silicon.
    B) iron.
    C) oxygen.
    D) carbon.
    E) uranium.

29. If it gains sufficient mass, a white dwarf can become a
    A) type II supernova.
    B) black dwarf.
    C) brown dwarf.
    D) type I supernova.
    E) planetary nebula.

30. For a white dwarf to explode entirely as a Type I supernova, it's mass must be
    A) 1.4 solar masses, the Chandrasekhar Limit.
    B) 3 solar masses, the Schwartzschild Limit.
    C) 100 solar masses, the most massive known stars.
    D) 20 solar masses, the Hubble Limit.
    E) at least 0.08 solar masses.

31. The heaviest nuclei of all are formed
    A) in the horizontal branch.
    B) in the ejection of matter in the planetary nebula.
    C) during nova explosions.
    D) in dense white dwarfs.
    E) in the core collapse that set the stage of Type II supernovae.

32. The Chandrasekhar Limit is
    A) the temperature at which hydrogen fusion starts.
    B) the lower mass limit for a Type II supernova.
    C) the point at which a planetary nebula forms.
    D) the temperature at which helium fusion starts.
    E) the upper mass limit for a white dwarf.

33. Where was supernova 1987A located?
    A) in the Orion Nebula, M-42
    B) in the sagitarius arm of the Milky Way, about 12,000 ly distant
    C) near the core of the Andromeda Galaxy, M-31
    D) in M-13, one of the closest of the evolved globular clusters
    E) in our companion galaxy, the Large Magellanic Cloud

34. Which of these events is not possible?
    A) white dwarfs and companion stars producing recurrent Type I supernova events
    B) low-mass stars swelling up to produce planetary nebulae
    C) a white dwarf being found in the center of a planetary nebula
    D) red giants exploding as Type II supernovae
    E) close binary stars producing recurrent novae explosions

35. Which of these does not depend on a close binary system to occur?
    A) a Type I supernova
    B) a nova
    C) a Type II supernova
    D) All of these need mass transfer to occur.
    E) None of these depend on mass transfer.

36. What can you conclude about a Type I supernova?
    A) It was originally a low-mass star.
    B) The star never reached the Chandrasekhar Limit.
    C) Its core was mostly iron.
    D) It was originally a high mass star.
    E) Its spectrum will show large amounts of hydrogen.

37. A recurrent nova could eventually build up to a
    A) Type I supernova.
    B) quasar.
    C) hypernova.
    D) Type II supernova.
    E) planetary nebula.

38. The brightest stars in a young open cluster will be
    A) yellow giants like our Sun, but much larger.
    B) massive blue stars at the top left on the H-R diagram.
    C) the core stars of planetary nebulae.
    D) red T-tauri stars still heading for the main sequence.
    E) red giants that are fusing helium into carbon.

39. What is the typical age for a globular cluster associated with our Milky Way?
    A) a few million years
    B) 200 million years
    C) a billion years
    D) 10-12 billion years
    E) 45 billion years

40. Which is used observationally to determine the age of a star cluster?
    A) the ratio of giants to supergiants
    B) the number of white dwarfs
    C) the total number of main sequence stars
    D) the amount of dust that lies around the cluster
    E) the luminosity of the main sequence turn-off point

41. Noting the turnoff mass in a star cluster allows you to determine its
    A) distance.
    B) number of stars.
    C) age.
    D) total mass.
    E) radial velocity.

42. The brightest stars in aging globular clusters will be
    A) massive blue main sequence stars like Spica.
    B) blue stragglers.
    C) red supergiants like Betelguese and Antares.
    D) core stars of planetary nebulae
    E) blue supergiants like Rigel and Deneb.

43. In a fairly young star cluster, if the most massive stars are swelling up into giants, the least
    A) massive stars are
    B) still evolving toward their ZAMS positions.
    C) blowing off shells as planetary nebula instead.
    D) continuing to shine as stable main sequence stars.
    E) collapsing directly to white dwarfs.
    F) also evolving off the main sequence as well.

44. Compared to a cluster containing type O and B stars, a cluster with only type F and cooler stars
    A) will be
    B) older.
    C) younger.
    D) further away.
    E) less obscured by dust.
    F) more obscured by dust.

45. Which stars in globular clusters are believed to be examples of mergers?
    A) blue stragglers
    B) planetary nebulae cores
    C) blue supergiants
    D) eclipsing binaries
    E) brown dwarfs

46. What was most surprising about SN 1987 A?
    A) It did not produce the flood of neutrinos our models had led us to expect.
    B) Its pulsar appeared within weeks of the explosion.
    C) The parent star was a blue supergiant, much like Deneb or Rigel.
    D) The supernova was not even in our own Galaxy.
    E) The supernova was luminous enough to see with the naked eye.

47. What made supernova 1987A so useful?
    A) It was spotted while still on the rise, and its light curve is well established.
    B) The Hubble Space Telescope was available for high resolution images.
    C) As it was in the Large Magellanic Cloud, we knew it was 170,000 ly distant.
    D) Its parent star had been studied previously.
    E) All of the above are true.